Abstract

In this thesis two different perturbative and elementary extensions of the Standard Model are presented. In the first model the Standard model is extended to a SU(4) $\sim$ SO(6) symmetry which breaks spontaneously to Sp(4) $\sim$ SO(5), leaving 5 Goldstone bosons. Three of them become the longitudinal components of the electroweak gauge bosons, one is an elementary pseudo Goldstone boson Higgs, and the last one is a good pseudo Goldstone boson Dark Matter candidate, since it is stable and neutral with respect to the Standard Model.

When the one-loop correction is calculated using the Coleman-Weinberg potential, the SU(4) is no longer preserved, but is broken to Sp(4) by the the Yukawa, and the electroweak gauge interactions, and the Goldstone bosons acquire a nonzero mass and become pseudo Goldstone bosons. At this point the mass matrix will no longer be diagonal, but there will be a mass mixing between the σ field and the fourth pseudo Goldstone boson. One of the mass eigenstate of this mixing is identified with the observed Higgs Boson. The one-loop corrections from the top dominates, and the vacuum is aligned in the direction, where the observed Higgs Boson is mostly a pseudo Goldstone boson.

Since the breaking pattern SU(4) $\rightarrow$ Sp(4) is isomorphic to SO(6) $\rightarrow$ SO(5), the other model examined is an SO(N) $\rightarrow$ SO($N-1$) model. The minimal number of Goldstone bosons required to obtain the Higgs as a pseudo Goldstone boson is 4, hence the minimal SO(N) model is SO(5) $\rightarrow$ SO(4) which is then the second model examined in this thesis.

Imposing that the SO(N) $\rightarrow$ SO($N-1$) has to reproduce the correct masses for the Standard model particles, the SO(N) $\rightarrow$ SO($N-1$) model has a vacuum alignment problem which the SU(4) $\rightarrow$ Sp(4) model has not. Two solutions to this vacuum alignment problem are presented for SO(5) $\rightarrow$ SO(4), the first is to add an extra scalar field, and the other is to add an explicit symmetry breaking term.

The beta functions for both of these models will be presented, and the behaviour of the couplings at high energy will be examined.